Intel® Pentium® 4 Processor with HT Technology

Next-Generation Performance for Today's Multitasking Business Environments

Hyper-Threading Technology

Contents

Executive Summary

Hyper-Threading (HT) Technology is a groundbreaking innovation from Intel that improves PC responsiveness, produces performance gains of up to 25 percent[1], and exemplifies Intel's leadership in delivering world-class technology beyond sheer processor speed. Pioneered in the Intel® Xeon™ processors for servers, HT Technology is now available for the desktop across a range of performance and system price levels. HT Technology provides a significant performance boost that is particularly suited to today's business computing climate, applications, and operating systems.

HT Technology enhances the Intel® Pentium® 4 processor's NetBurst™ microarchitecture to enable a single Pentium 4 processor to execute two threads simultaneously. This improves performance by allowing operating systems designed for HT Technology to utilize processor resources that otherwise would sit idle. In deploying Intel® Pentium® 4 Processor with HT Technology PCs, IT organizations gain more performance to run background tasks such as virus checking, e-mail encryption, and file compression, thereby making the overall infrastructure more robust, manageable, and secure. End users see an immediate performance impact in today's multitasking environments, with increased responsiveness on current operating systems, applications, and background tasks.

HT Technology requires a computer system with an Intel Pentium 4 processor supporting HT Technology, a Hyper-Threading Technology enabled chipset and BIOS, and an operating system such as Microsoft Windows* XP Professional or certain versions of Linux* that are optimized for HT Technology. To ensure the PCs you buy deliver the full benefits of Hyper-Threading Technology, look for the Intel Pentium 4 Processor with HT Technology logo, which indicates that your system vendor has verified the platform supports HT Technology.

Introduction: Performance for Today's Business Desktop

Today's business climate is characterized by its fast pace, competitive pressures, and attention to the bottom line. In this environment, Information Technology (IT) must select and deploy technologies that empower users to make the most of an information-rich environment, while scrutinizing each investment to make sure it will deliver clear business value. At the same time, IT organizations are counting on their desktop clients not only to give users the power of sophisticated operating systems and applications, but also to run IT-oriented background tasks designed to make the overall infrastructure more robust.

Meanwhile, end users are pressed to accomplish more, even as they struggle with a flood of information and the need to interact with a larger set of individuals along the company's value chain. In this highly charged, interconnected environment, business PC users are increasingly likely not only to run a wide range of feature-rich applications, but also to multitask among them, using several applications simultaneously.

As a result, businesses need a new approach to performance—to keep systems responsive and users operating at peak efficiency despite the demands of today's multitasking and background processing environments.

To meet these needs, Intel has enhanced the Pentium 4 processor to bring to the desktop new capabilities that are ideally suited to the way users and IT organizations work today. *Hyper-Threading Technology* increases system responsiveness and produces performance gains of up to 25 percent, giving IT the power to run background processes and business users the ability to do more at once. The upshot: Companies can enhance business productivity, reduce IT management costs, increase the security and robustness of their information infrastructure, and gain a competitive edge.

Fulfilling Intel's Commitment

Intel's commitment to providing businesses with best-in-class performance is longstanding. In 1965, Gordon Moore, who went on to co-found Intel and is now Chairman Emeritus of the Intel Board of Directors, predicted that the number of transistors on a chip could double each year through 1970. Moore saw that this doubling would create a spiral of continued performance improvements and increased value. More than 35 years later, Intel's advances have made Moore's Law an engine of economic progress and business productivity, with each new processor introduction and microarchitecture shift delivering significant performance advances and demonstrating Moore's foresight.

Intel has used a variety of approaches to drive system performance upward. Faster clock speeds are one of the most widely recognized ways of adding performance. Higher clock frequencies boost performance by increasing the number of instructions that can be executed each second.

But faster clocks are only one of many ways to raise performance. A second approach focuses on fully utilizing the processor's resources and enabling the processor to accomplish more work in each clock cycle. Microarchitecture techniques to raise performance have included super-pipelining, branch prediction, and super-scalar execution. Similarly, larger and deeper caches improve performance by providing faster access to frequently used data or instructions and keeping the processor core working efficiently.

HT Technology is very much in line with this second approach. In fact, in delivering significant performance increases tailored to the way businesses run and the way modern applications and operating systems are written, HT Technology represents a landmark in Intel® processor technology design.

[1] Performance will vary depending on the specific hardware and software you use. See http://www.intel.com/info/hyperthreading/ for information.

Seeing Double

In computers, as in everyday life, many tasks can be efficiently accomplished in parallel. Consequently, many software programs enhance performance by dividing their workloads into multiple threads and processes—instruction streams that can be independently scheduled and dispatched. In a system with multiple processors, these threads and processes (for simplicity's sake, we'll call them threads) can be executed independently, in parallel, on different processors, accomplishing more work in the same amount of time.

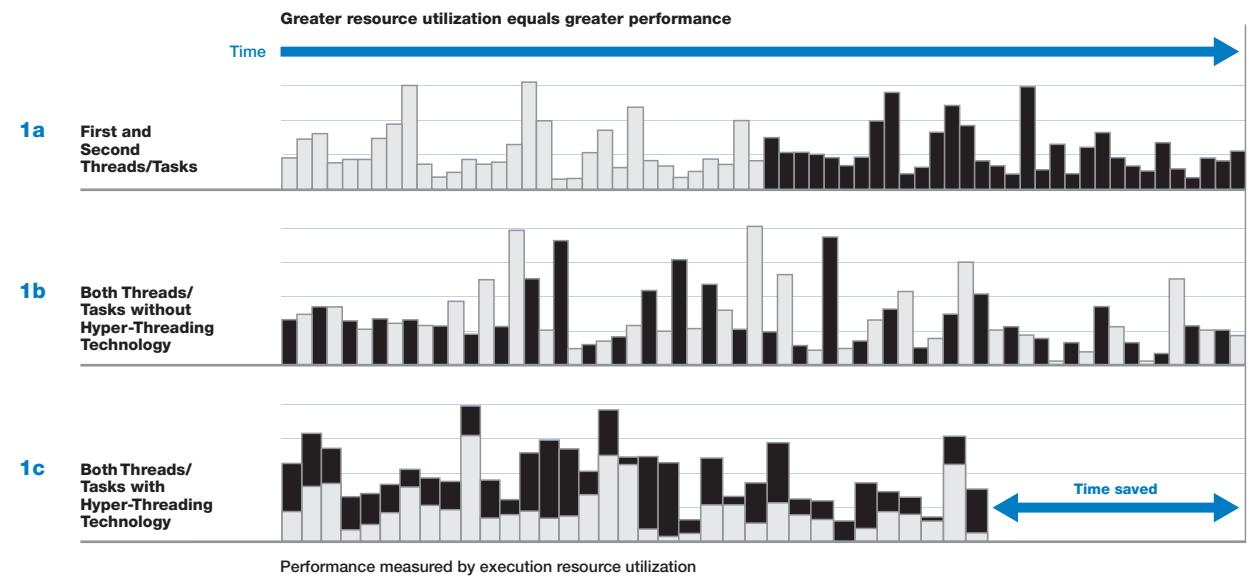
Hyper-Threading Technology is an enhancement to the Intel® NetBurst™ microarchitecture that allows two threads to run independently and in parallel on a *single* Intel Pentium 4 processor enabled with HT Technology. An HT Technology-aware operating system such as Microsoft Windows XP Professional "sees" a single *physical* Pentium 4 processor as two *virtual* or *logical* processors and gives each virtual processor a thread to work on. The processor allocates execution resources—cache memories, execution units, buses, and so forth—between the two logical processors. By using resources that otherwise would be idle, the Pentium 4 Processor with HT Technology enhances overall system performance.

This approach is a bit like riding an exercise bike while reading a book. You're performing the two tasks in parallel, using different "resources"—your legs and eyes. At the end of your workout, you've accomplished more than if you had been only riding the bike or only reading the book. You worked on two tasks (or threads) simultaneously, used resources that otherwise would have been idle and performed more work in the same amount of time. You were more productive.

As Figure 1 shows, greater resource utilization equals greater performance. Figure 1 also indicates how Hyper-Threading Technology compares to multitasking.

- Figure 1a illustrates the use of execution resources for two tasks that are executed sequentially. The entire first task is run, followed by the second task.
- Figure 1b depicts a multitasking operating system without HT Technology. Here, the codes for two tasks are interleaved, with each task having full control of processor resources for alternating time slices. The total time to complete the two tasks is the same, whether they run interleaved or back to back. In reality, the interleaved tasks may run slightly slower because of cache issues and task switching overhead.
- Figure 1c shows an HT Technology-enabled PC. The two tasks (threads) share execution resources. At any given time, execution resources may be working on code from either thread. Overall CPU utilization is significantly higher, and the two threads/tasks complete in less time than they did on the multitasking or single-tasking system. The stacking of the two bars depicts the two threads using non-conflicting execution resources at the same time.

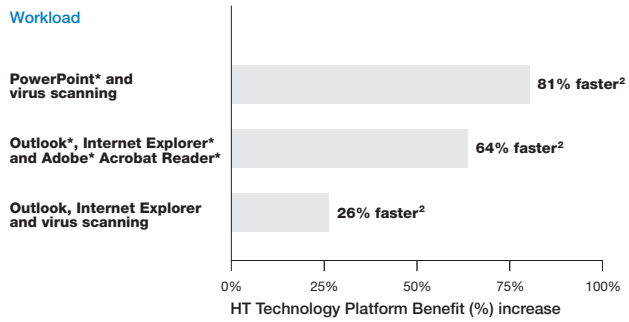
Figure 1: Resource Utilization and Performance



With an HT Technology-enabled PC, both threads are executed simultaneously, increasing the efficiency of CPU resource utilization and performing the two tasks up to 25 percent faster.

Figure 2: Hyper-Threading Technology Enhances Productivity

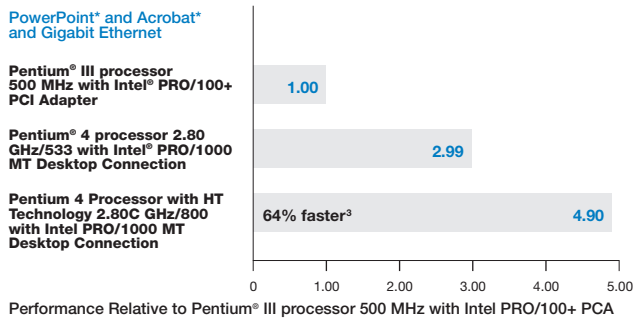
2a: Hyper-Threading Technology Platform Multitasking Benefits



[2]When comparing an Intel® Pentium® 4 Processor with HT Technology at 2.80C GHz/Intel® 865G 800-MHz SB to an Intel Pentium 4 processor 2.80 GHz/Intel® 865G 533 SB

Source: Intel® Configuration: Intel® Pentium® 4 processor 2.80 GHz/533 MHz – Intel® 865G Desktop Board, 512-MB DDR333 CL2.5-3-3; Intel® Pentium® 4 Processor with HT Technology 2.80C GHz/800 MHz – Intel® 865G Desktop Board, 512-MB DDR333 CL2.5-3-3; All Platforms Except Pentium® III Processor Integrated graphics with Intel® Extreme Graphics 2, Graphics Driver Beta Candidate 6.13.01.3314, Microsoft* Default UDMA-5, Intel® Chipset Software Installation Utility 5.00.1003 beta, IBM* 80GB 120GXP IC35L080AVVA07-0 ATA-100 Hard Drive; Intel® C & FORTRAN compilers 6.0 for SPEC, DirectX* 8.1, Windows* XP Build 2600 SP1, 100 Mbps Intel® Pro/100+ Management PCI LAN Card. *Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance.*

2b: Intel® Pentium® 4 Processor with HT Technology and Gigabit Ethernet Benefits



[3]When comparing an Intel® Pentium® 4 Processor with HT Technology at 2.80C GHz/800 SB with the Intel® PRO/1000 MT Desktop Connection to a Pentium 4 processor 2.80 GHz/533 SB with the Intel PRO/1000 CT Desktop Connection

Source: Intel® Configuration: Intel® Pentium® III processor at 500 MHz – Intel® Desktop Board SE440BX-2, 128-MB PC100 CL2 SDRAM, Leadtek* WinFast GeForce* 3/ nVidia* GeForce 3 4x AGP Graphics, nVidia Detonator* 3 reference driver 21.81, IBM* DTLA-307030 30GB ATA-100 Hard Drive, Intel® Application Accelerator v1.1, Windows* XP default driver Ultra DMA Mode 2; Intel® Pentium® 4 processor 2.80 GHz/533 MHz – Intel® 865G Desktop Board, 512-MB DDR333 CL2.5-3-3; Pentium® 4 Processor with HT Technology 2.80C GHz/800 MHz – Intel® 865G Desktop Board, 512-MB DDR333 CL2.5-3-3; All Platforms Except Pentium® III Processor Integrated graphics with Intel® Extreme Graphics 2, Graphics Driver Beta Candidate 6.13.01.3314, Microsoft* Default UDMA-5, Intel® Chipset Software Installation Utility 5.00.1003 beta, Seagate* 40GB ST340016A ATA-100 Hard Drive; Intel® C & FORTRAN compilers 7.0 for SPEC, DirectX* 8.1, Windows XP Build 2600 SP1, Intel® Pro/100+ Management PCI LAN Card, Intel® Pro/1000 MT Desktop Connection. *Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance.*

In multitasking environments, Hyper-Threading Technology enables IT to run background computing tasks without degrading system responsiveness, and empowers users to run demanding applications simultaneously. Figure 2a shows performance enhancements for a variety of application combinations. Figure 2b depicts performance of a workload that included simultaneously using PowerPoint and Acrobat files while interfacing over Gigabit Ethernet. With this workload, an Intel® Pentium® 4 Processor with HT Technology at 2.80C GHz and an 800-MHz system bus ran 64 percent faster than the Pentium 4 processor at 2.80 GHz with a 533-MHz system bus and without HT Technology. In addition, the Pentium 4 Processor with HT Technology at 2.80C GHz and an 800-MHz system bus and an Intel® PRO/1000 MT Gigabit Ethernet connection ran over four times faster than a Pentium® III processor 500 MHz with only a fast Ethernet connection.

Performance Enhancements for the Way Business Works

Hyper-Threading Technology delivers measurable benefits when users are working with multiple applications simultaneously, running IT-oriented background processes, or running a single multithreaded application.

Multitasking Environments

In a multitasking environment, Hyper-Threading Technology produces performance improvements that increase user productivity, allow users to get more done in less time and enable IT to run background computing tasks while minimizing the loss in system responsiveness. Figure 2 depicts performance increases for typical multitasking scenarios.

Multitasking environments include a variety of scenarios, including:

- A user simultaneously running several computationally intensive foreground applications.
- A user simultaneously running a computationally intensive foreground application and a background application.
- A user running a computationally intensive foreground application while IT-oriented background tasks execute simultaneously.

HT Technology's added performance for multitasking environments has a significant impact on the costs, manageability, and robustness of the IT infrastructure, as well as on user productivity and satisfaction. The boost to multitasking performance means that IT can more readily deploy background processes such as file and e-mail encryption and decryption, compression and decompression, and virus scanning that make the data more secure, preserve bandwidth, and minimize storage requirements. On underpowered systems, these background processes can noticeably slow system responsiveness, which can lower productivity, and lead users to avoid these processes where possible. By boosting system responsiveness, HT Technology promotes productivity, and makes it more likely that these best practice processes will be consistently used. HT Technology also enhances the user's ability to take advantage of new productivity-enhancing features without incurring a performance penalty.

Case in point: Virus scans are an essential element of corporate information security, but in the past have often caused a performance drain. With Hyper-Threading Technology, the PC remains highly responsive—and the user remains productive—even when a virus scan is running while the user performs another compute-intensive task. For example, users often need to quickly share information that they find on the Web. Internet Explorer* saves users time by making it easy to e-mail a Web page without having to launch Outlook* separately. With HT Technology, the user doesn't have to wait as long while the computer opens a new mail message, and embeds the Web page, even with virus scanning running in the background. This combination of tasks ran 26 percent faster on a Pentium 4 processor-based PC enabled with Hyper-Threading Technology

than on a similar platform without HT Technology.[2] Similarly, running a virus scan while opening a graphics-rich PowerPoint* presentation that's stored on the user's hard disk was 81 percent faster on an HT Technology-enabled system than on a similar system without HT Technology.

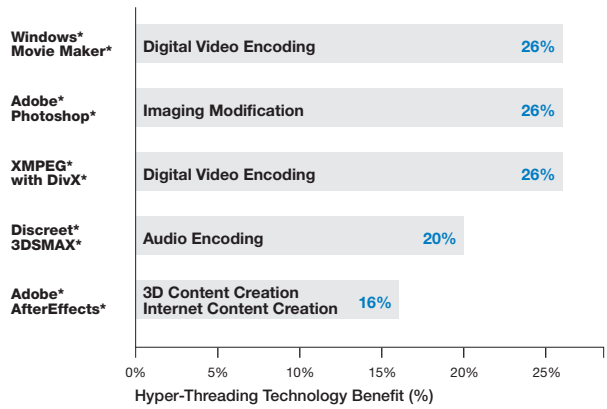
Using HT Technology in a multitasking environment requires either Windows XP Professional or a version of Linux that supports HT Technology. Additional application software optimizations or rewrites are not necessary to receive the multitasking benefits of HT Technology.

New Usage Models

HT Technology allows users to work in ways that were previously impractical. For instance, the performance limitations of past systems have meant that users who were working on a highly processor-intensive task, such as creating Web content or analyzing complex spreadsheet data, had to wait until that task completed before using their PC for anything else. With a PC based on the Intel Pentium 4 Processor with HT Technology, however, the user is much better able to run multiple applications, even if one of them is highly compute intensive. Consider these multitasking usage scenarios[4]:

- Gigabit Ethernet (GbE) is increasingly viable on the desktop, thanks in part to advances that make 10/100/1000 Mbps network speeds possible on the same wire. With HT Technology, the PC remains responsive, and keeps network data flowing at high speeds even when the user is performing a complex, computationally intensive task such as publishing a presentation to PDF format. For example, publishing a large presentation to PDF while simultaneously downloading a large file from the company intranet ran 64 percent faster on a Pentium 4 Processor with HT Technology 2.80C GHz and an 800-MHz system bus than on a similarly configured PC with a 533-MHz system bus and no HT Technology.[3]
- A power user whose job involves content creation for the company's Web site can now run Flash* Author and Flash Player simultaneously. In a typical scenario, the user imports a Flash file into a new authoring session. While waiting for this task to complete, the user decides to review a recently completed Flash Media clip. Without HT Technology, the user faces a 10 second or longer delay for the Flash clip to be exported. With HT Technology, the clip opens immediately, as if no background task was running at all.
- A data analytics expert can run powerful data analysis and data mining software simultaneously. An employee might be working on a SAS* report while a large Excel* worksheet recalculates statistics in the background. Without HT Technology, the user would have to wait for the spreadsheet calculations to complete before completing the SAS report. With HT Technology, the system remains responsive while the user performs both tasks. The user saves valuable time and his or her teammates get the report they need a few minutes sooner, allowing them to make decisions more quickly and with better information at hand.

Figure 3: HT Technology Impact on Multithreaded Applications



These comparison graphs show the percentage improvement in performance in identical systems based on the Intel® Pentium® 4 processor 3.06 GHz supporting Hyper-Threading Technology; the only difference being that in one system, HT Technology is enabled, while in the base system, it is not. Source: Intel® Configuration: Pentium® 4 processor at 3.06 GHz with Hyper-Threading Technology (Enabled/Disabled)—Intel® Desktop Board D850EMV2, 256-MB PC1066 RDRAM, All Platforms—Leadtek* WinFast A250 Ultra TD GeForce* 4/ nVidia* GeForce 4 4x AGP Graphics, nVidia Detonator* 4 reference driver 28.32; Intel® Application Accelerator v2.2.2128, Intel® Chipset Software Installation Utility v4.00.1009, IBM* 80GB 120GXP IC35L080AVVA07-0 ATA-100 Hard Drive; Intel® C & FORTRAN compilers 6.0 for SPEC, DirectX* 8.1, Windows* XP (build 2600), 100 Mbps Intel® Pro/100+ Management PCI LAN Card. *Performance will vary depending on the specific hardware and software you use. See http://www.intel.com/info/hyperthreading/ for information.*

Many leading desktop applications can take immediate advantage of HT Technology, handing users performance increases of 16–26 percent.

Multithreaded Applications

A range of widely used business applications are already written with multiple threads. These applications can run without modifications and will benefit automatically from HT Technology if they are threaded to correctly use disparate processor resources simultaneously. The level of performance benefit gained will depend in part on how well the multithreaded code utilizes the processor's resources. As Figure 3 shows, a variety of current software packages demonstrate HT Technology's performance impact.

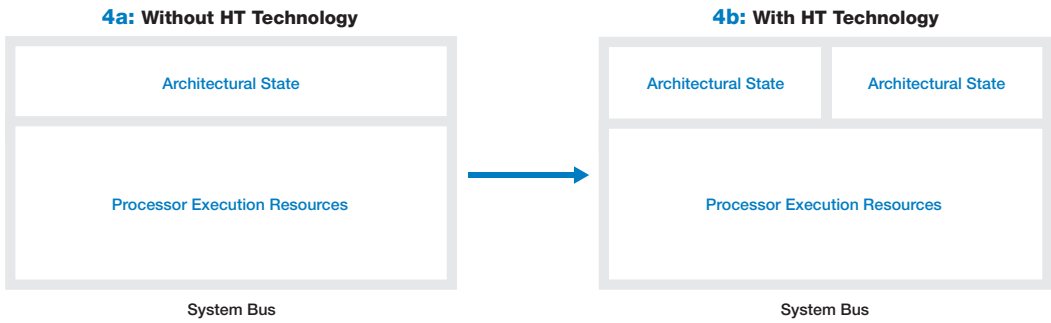
As applications increasingly are written to take greater advantage of processor parallelism, HT Technology provides an additional boost for newer capabilities and the growing needs of today's businesses. Intel has undertaken a broad program of industry-enabling and validation efforts to drive multithreading as a widely accepted architecture for desktop applications, and to ensure that HT Technology is compatible with a broad range of applications and devices.

A Closer Look

HT Technology enables two threads to share the processor's execution resources. It accomplishes this by giving each logical processor its own architectural state, with its own set of general-purpose registers, control registers, and so forth. With that accomplished, logical processors can share other physical

[4] See http://www.intel.com/eBusiness/products/desktop/p4p/benefits/ht/ar024604.htm for a demo showing HT Technology's impact in these scenarios.

Figure 4: One Processor, Two Architectural States



An Intel® Pentium® 4 processor supporting HT Technology gives each thread a separate architectural state, creating two "logical" processors on a single physical processor.

resources, including caches, execution units, and buses. The Intel Pentium 4 Processor with HT Technology manages incoming data from different software applications and continuously switches from one set of instructions to the other, every few nanoseconds, without losing track of the data processing status of each set of instructions.

Thread-Level Processing

Hyper-Threading Technology implements thread-level parallelism to increase the utilization of the Pentium 4 processor's execution resources and thereby improve performance. Thread-level parallelism can be implemented in several different ways. In servers and high-end workstations, thread-level parallelism is implemented through physical multiprocessing: assigning different threads to different processors in a system that has multiple processors. (The Intel Xeon processor and Intel Xeon processor MP combine physical multiprocessing with HT Technology.)

In implementing thread-level parallelism in a single-processor system, the goal is to maximize performance without requiring a larger die size, raising power requirements or significantly adding to the processor's physical complexity (which would make the chip more difficult and expensive to manufacture). Among the available approaches:

- **Chip multiprocessing (CMP).** Two processors are located on a single die. Each processor has a full set of execution and architectural resources, and the two may share an on-chip cache. CMP chips are significantly larger than single-core chips, and are therefore more expensive to manufacture and hotter to run.
- **Time-slice multithreading.** A single processor executes multiple threads by switching between them after a fixed time period. This approach can result in wasted execution slots.
- **Switch-on-event multithreading.** A single processor switches threads when an event occurs such as a cache miss, which has a long latency. Both time-slice and switch-on-event multithreading result in less-than-optimal resource usage.
- **Simultaneous multithreading.** Multiple threads execute simultaneously on a single processor without switching from one to the other. Since threads execute simultaneously, they make the most effective use of processor resources. They also deliver maximum performance with minimal impact on chip complexity, die size, and power consumption.

HT Technology implements thread-level parallelism through simultaneous multithreading. HT Technology enables two threads to execute in parallel, maintaining their own architectural state and sharing other processor resources. Instructions from both threads are simultaneously dispatched for execution by the processor core. The processor core executes the two threads concurrently, using out-of-order instruction scheduling to keep as many of its execution units as possible busy during each clock cycle.

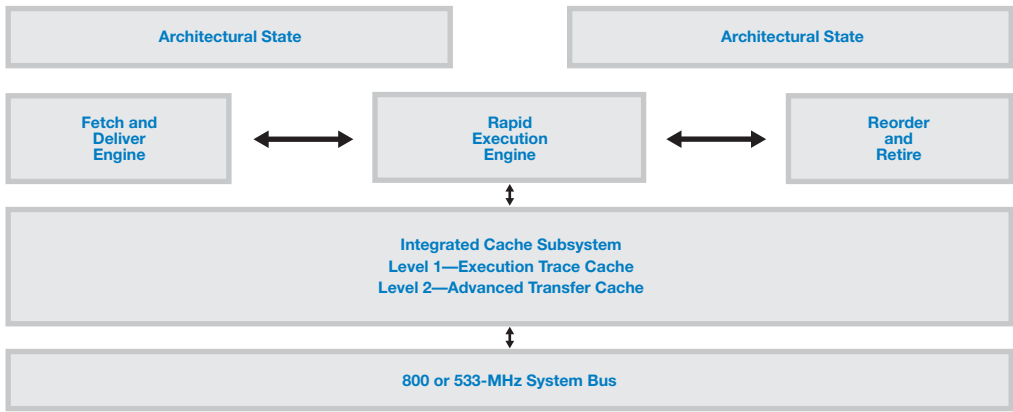
Under the Hood

Hyper-Threading Technology works by duplicating the architectural state on each processor, while sharing one set of processor execution resources. The architectural state tracks the flow of a program or thread, and the execution resources are the units on the processor that do the work: add, multiply, load, etc.

Figure 4a represents an Intel Pentium 4 processor (no HT Technology). The processor has a single set of processor execution resources and a single architectural state. Figure 4b depicts a Pentium 4 processor with HT Technology. The processor still has one set of execution resources, but now has two architectural states—one for each thread.

When scheduling threads, the operating system treats the two architectural states as two logical processors. Multiprocessor-capable or multithreaded software can run unmodified on the two logical processors. Each logical processor can respond to interrupts independently. The first logical processor can track one software thread while the second logical processor tracks another software thread simultaneously. The second thread uses resources that would be unused if only one thread were executing. For example, one logical processor might execute a floating-point operation while the other logical processor executes an addition and a load operation. The result is increased utilization of the execution resources and higher processing throughput.

Figure 5: Intel® Pentium® 4 Processor Supporting HT Technology Block Diagram



Intel® Pentium® 4 processor supporting HT Technology resources work together to execute two threads on two logical processors.

Here's how the Pentium 4 processor's resources (Figure 5) work together to implement HT Technology:

- **Fetch and Deliver Engine.** The Fetch and Deliver engine alternately fetches instructions from each logical processor and sends these instructions to the Rapid Execution Engine for processing. At the Execution Trace Cache, one line is fetched for one logical processor, and then one line is fetched for the other logical processor. This continues, alternating back and forth, as long as both logical processors need to use the Execution Trace Cache. If one logical processor is not requesting use of the cache, then the other can use the Execution Trace Cache's full bandwidth.
- **Rapid Execution Engine.** At the Rapid Execution Engine, both logical processors execute simultaneously. The Rapid Execution Engine takes instructions from the instruction queues and sends them to the execution units as fast as it can. Instructions are selected based only on dependencies and availability of execution units. The instructions may be selected out-of-order, allowing later instructions that are independent to be scheduled before earlier instructions. The execution core is for the most part oblivious to what instructions belong to which logical processor, and the schedulers do not distinguish between instructions of different logical processors. The schedulers simply map independent instructions in the instruction queues to available execution resources. For example, a scheduler may map two instructions from thread #1 and one instruction from thread #2 in the same cycle.
- **Reorder and Retire Block.** The Reorder and Retire block takes all the instructions that were executing out-of-order, puts them back into program order and commits the state of those instructions in program order. Instructions are alternately retired for one logical processor, then the other.
- **Cache Memory.** The processor's cache memory delivers data and instructions to the processor core at a high speed. Cache memory is shared by both logical processors and is designed to minimize potential cache conflicts through a high level of set-associativity, which helps ensure data is well retained in the caches.
- **System Bus.** The Pentium 4 processor's 800 or 533-MHz system bus increases the throughput of multitasking operating systems and multithreaded applications, and provides the necessary bandwidth for Hyper-Threading Technology when accessing system memory. When one logical processor cannot find the data it needs in cache memory, the data is transferred over the system bus from random access memory.

BIOS, Operating System, and Application Support for HT Technology

BIOS, operating system, and application support are key aspects of enabling Hyper-Threading Technology.

BIOS Support

Pentium 4 Processor with HT Technology-based systems have implemented changes in the platform BIOS so the system recognizes the logical processors. During the system boot process, the BIOS counts and records the number of logical processors available in the system and records the information in the Pentium 4 processor's Advanced Configuration and Power Interface (ACPI) table. The operating system then uses this table to schedule threads onto the logical processors.

Operating System Support

Microsoft Windows XP and certain versions of Linux are optimized for HT Technology. Intel does not recommend the use of HT Technology with other operating systems.

In Windows XP Professional, the operating system uses the CPUID instruction mechanism to identify an HT Technology-enabled microprocessor. The Windows XP Professional licensing model is HT Technology-aware and is licensed for two physical processors or four total (physical and logical) processors. Intel recommends that customers use Service Pack 1 with Microsoft Windows XP Professional.

Certain versions of the Linux operating system such as RedHat* Linux 9 (Professional and Personal versions), RedFlag* Linux Desktop 4.0, and SuSe* Linux 8.2 (Professional and Personal versions) include optimizations for HT Technology. If you are purchasing a Linux operating system-based PC, check with your PC vendor to determine if the PC meets the HT Technology platform requirements, HT Technology is enabled, and the operating system is optimized for HT Technology.

Application Support

In a *multitasking* environment, HT Technology delivers noticeable performance increases over current software, with no code modifications needed. Beyond these clear and immediate benefits for current applications, HT Technology can further enhance performance for *multithreaded* applications. The increases seen will vary depending on the nature of the application, the threading model it uses, and various system dependencies.

Although existing multithreaded applications will run correctly on a PC based on the Pentium 4 Processor with HT Technology, code modifications are recommended to get the optimum benefit of this technology. Many software developers have embraced Hyper-Threading Technology and architected their applications to take full advantage of HT Technology's unique capabilities.

Applications use the operating system to schedule threads across the multiple logical processors available in the system, much as they do on traditional multiprocessor systems. The system BIOS and operating system determine which logical processor is available for use.

Intel has an industry-leading compatibility and validation program in place for Hyper-Threading Technology. Intel, Microsoft, and many software vendors have performed compatibility testing on leading business applications. Windows applications that can run in a multiprocessor environment should also run unmodified, without error, on a system based on the Pentium 4 Processor with HT Technology.

Transitioning to HT Technology

HT Technology is a dramatic advance in processor design that affords a broad range of practical benefits to business users and information technology departments. To ensure a smooth transition to HT Technology, IT managers will want to be aware of platform requirements, maximize the stability of enterprise platforms and software images, evaluate the compatibility of current software, and design corporate software to take advantage of HT Technology.

Platform Requirements

An HT Technology-enabled PC must include:

- An Intel Pentium 4 processor that supports HT Technology
- A chipset that supports HT Technology
- A BIOS that recognizes HT Technology
- An operating system optimized for HT Technology

The easiest way to make sure the PCs you buy deliver the full benefits of Hyper-Threading Technology is to choose systems with the Intel Pentium 4 Processor with HT Technology logo. This logo means that your system vendor has verified that the system supports HT Technology.

Platform and Image Stability

Intel understands the importance of platform stability and specifically the need to maintain stable software images. Therefore, although Hyper-Threading Technology has been available since end-2002, only in 2003, with the introduction of the Intel® 865G chipset, has Intel recommended that organizations deploy HT Technology to mainstream business users. Intel recommends transitioning immediately to PCs based on the Intel Pentium 4 processor supporting HT Technology and the Intel 865G chipset as your corporate stable platform. The Intel 865G chipset offers a variety of high-performance capabilities, including high-bandwidth interfaces, an 800-MHz system bus, a new Communication Streaming Architecture for wire-speed Gigabit Ethernet, and an integrated graphics controller with Intel® Extreme Graphics 2 technology. By transitioning now to PCs based on the Intel Pentium 4 processor supporting HT Technology and the Intel 865G chipset, your company can maximize the stability of your platforms and images as you enhance business productivity, information security, and infrastructure robustness.

To further smooth your transition to HT Technology, Intel recommends that your organization also transition to Windows XP Professional if you have not already done so. This new operating system is a required component of HT Technology functionality and provides added performance, functionality, and security for multitasking business computing environments. In addition, it is generally far more cost effective to deploy a new operating system and platform simultaneously rather than as separate steps.

Internally Developed Corporate Software

Based on extensive compatibility testing of prepackaged software, compatibility of internally developed corporate software will most likely not be a problem. However, Intel recommends you evaluate the HT Technology-enabled platform for software compatibility, just as you would any other new platform.

More importantly, Intel recommends that corporate software developers learn about HT Technology so software can be written with the proper threading to deliver the largest possible performance benefits. In general, the best way to enhance application performance on HT Technology-enabled systems is to ensure that threads executing on the two logical processors have minimal dependencies on the same shared resources on the physical processor. With an understanding of how the application threads and processes utilize the shared resources on an Intel Pentium 4 Processor with HT Technology, setting processor affinity to minimize competition for these system resources can help application performance.

Intel offers a powerful toolset to assist in adapting existing applications to take advantage of HT Technology. Intel® compilers and Intel® VTune™ Performance Analyzers include a full set of features to help applications get the most from this technology. Applications that are already multithreaded can take advantage of incremental tuning with Intel® Performance Libraries enabled with Hyper-Threading Technology, as well as programs offered by Intel® Developer Services, an online resource to assist software developers. A Web site of training materials, white papers, and other information to assist developers in utilizing HT Technology is available at http://developer.intel.com/technology/hyperthread/index.htm.

Bottom Line

HT Technology is a major advance that enables the Intel Pentium 4 processor to utilize its execution resources more efficiently. The combination of Hyper-Threading Technology with the Pentium 4 processor's high clock speeds and Intel NetBurst microarchitecture and the Intel 865G chipset delivers outstanding performance that enhances IT effectiveness, infrastructure robustness, and end-user productivity.

Deploying high-speed PC systems based on these technologies gives IT the ability to deploy critical background services that help keep information secure, reduce corporate IT expenditures, and make the environment more manageable—without having to worry about whether their PCs are up to the combined load of sophisticated applications and background services. By the same token, these PC systems give business users more performance where they need it most—in demanding multitasking environments. Users are free to take full advantage of powerful software that can help them perform at a higher level, make better decisions, solve their toughest business challenges, and ultimately make the company more agile and competitive. Moreover, HT Technology provides headroom for future growth and new capabilities, equipping the company to quickly adapt next-generation tools and applications.

Today's and tomorrow's enterprise leaders will deploy the Intel Pentium 4 Processor with HT Technology to gain a competitive advantage.

Learn More

See additional technical details on Hyper-Threading Technology at:
http://developer.intel.com/technology/hyperthread/index.htm
http://www.intel.com/info/hyperthreading/

Find additional information on the Intel Pentium 4 processor family at the Intel® Business Computing Web site:
http://www.intel.com/ebusiness/products/desktop/index.htm

Frequently Asked Questions About Hyper-Threading Technology

What is Hyper-Threading Technology?

It's a major enhancement to the Intel NetBurst microarchitecture that increases PC responsiveness and produces performance increases of up to 25 percent. HT Technology enables a single Intel Pentium 4 processor to present itself as two virtual processors. The processor can execute two threads simultaneously, using resources that otherwise would sit idle and accomplishing more work in the same amount of time.

How does HT Technology work?

HT Technology enables one Intel Pentium 4 processor to function as two logical processors, with each working on one application (in a multitasking environment) or one application thread (in a single multithreaded application) simultaneously. Logical processors share physical resources such as caches, execution units, and buses, but each has its own architectural state and its own set of general-purpose registers, control registers, and so forth.

Why should I deploy HT Technology?

HT Technology is a breakthrough that delivers more performance for the way users work. With this added performance, desktop users can do more at once, particularly in multitasking environments. Users can make the most of Windows XP Professional's Preemptive Multitasking Architecture to run demanding applications simultaneously while still maintaining system responsiveness. IT can comfortably run client background applications that make the computing infrastructure more secure, reliable, and manageable.

What do I need to implement Hyper-Threading Technology?

In addition to an Intel Pentium 4 processor that supports HT Technology, the system must include a chipset and BIOS that support HT Technology and an operating system optimized for HT Technology. To make sure the PCs you buy deliver the full benefits of Hyper-Threading Technology, look for systems with the Intel Pentium 4 Processor with HT Technology logo, which indicates that your system vendor has verified the platform utilizes HT Technology.

What desktop operating systems does Intel recommend using with Hyper-Threading Technology?

Intel recommends using Microsoft Windows XP Professional or certain versions of the Linux operating system such as RedHat Linux 9 (Professional and Personal versions), RedFlag Linux Desktop 4.0, and SuSe Linux 8.2 (Professional and Personal versions) that include optimizations for Hyper-Threading Technology.

Does Hyper-Threading Technology really give me two processors?

No—it just makes a single processor act like two, so it can execute two threads simultaneously. The threads can come from two different applications, or from two different processes or tasks within a single multithreaded application or operating system.

Will I have licensing problems with Windows XP Professional?

The licensing model for Windows XP Professional is HT Technology-aware. Windows XP Professional is licensed for two physical processors or four total (physical and logical) processors.

Is there an easy way to tell if a system supports Hyper-Threading Technology?

Yes. Look for systems with the Intel Pentium 4 Processor with HT Technology logo. This logo indicates the system vendor has verified support for HT Technology with Intel.

How do I manage the transition to HT Technology while maximizing the stability of my software images?

Move immediately to qualify PCs based on the Intel Pentium 4 Processor with HT Technology and the Intel 865G chipset, and make these systems your next corporate stable platforms. Evaluate the HT Technology-enabled platform for software compatibility, just as you would any other new platform.

Where can I learn more?

See:
http://developer.intel.com/technology/hyperthread/index.htm and http://www.intel.com/info/hyperthreading/

For more information, visit the Intel Web site at: **www.intel.com/info/hyperthreading/**

Look for systems with the Intel® Pentium® 4 Processor with HT Technology logo which your system vendor has verified utilize Hyper-Threading Technology. Hyper-Threading Technology requires a computer system with an Intel® Pentium® 4 processor supporting HT Technology and an HT Technology enabled chipset, BIOS, and operating system. Performance will vary depending on the specific hardware and software you use.

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